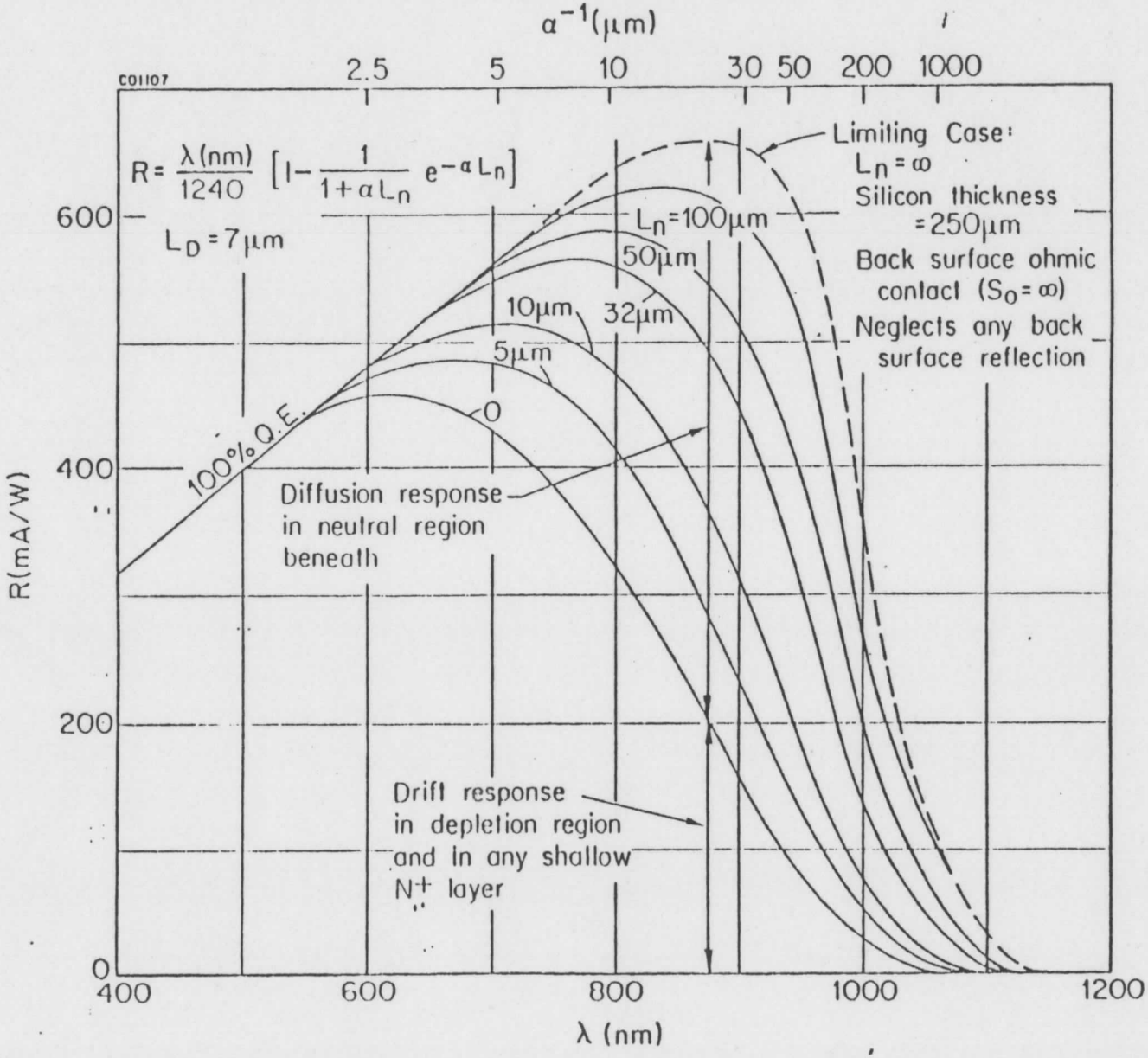
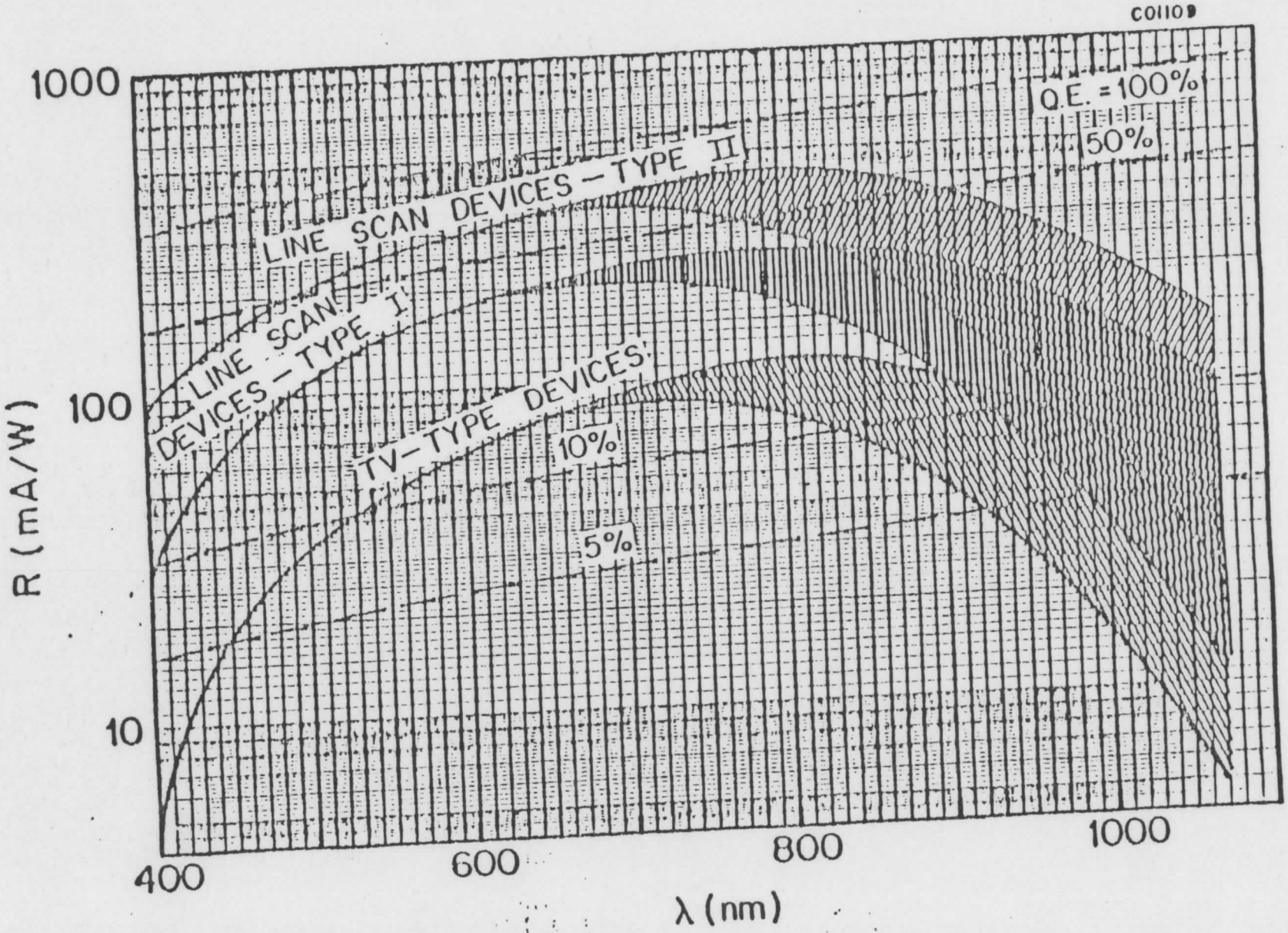
FAIRCHILD

C C D

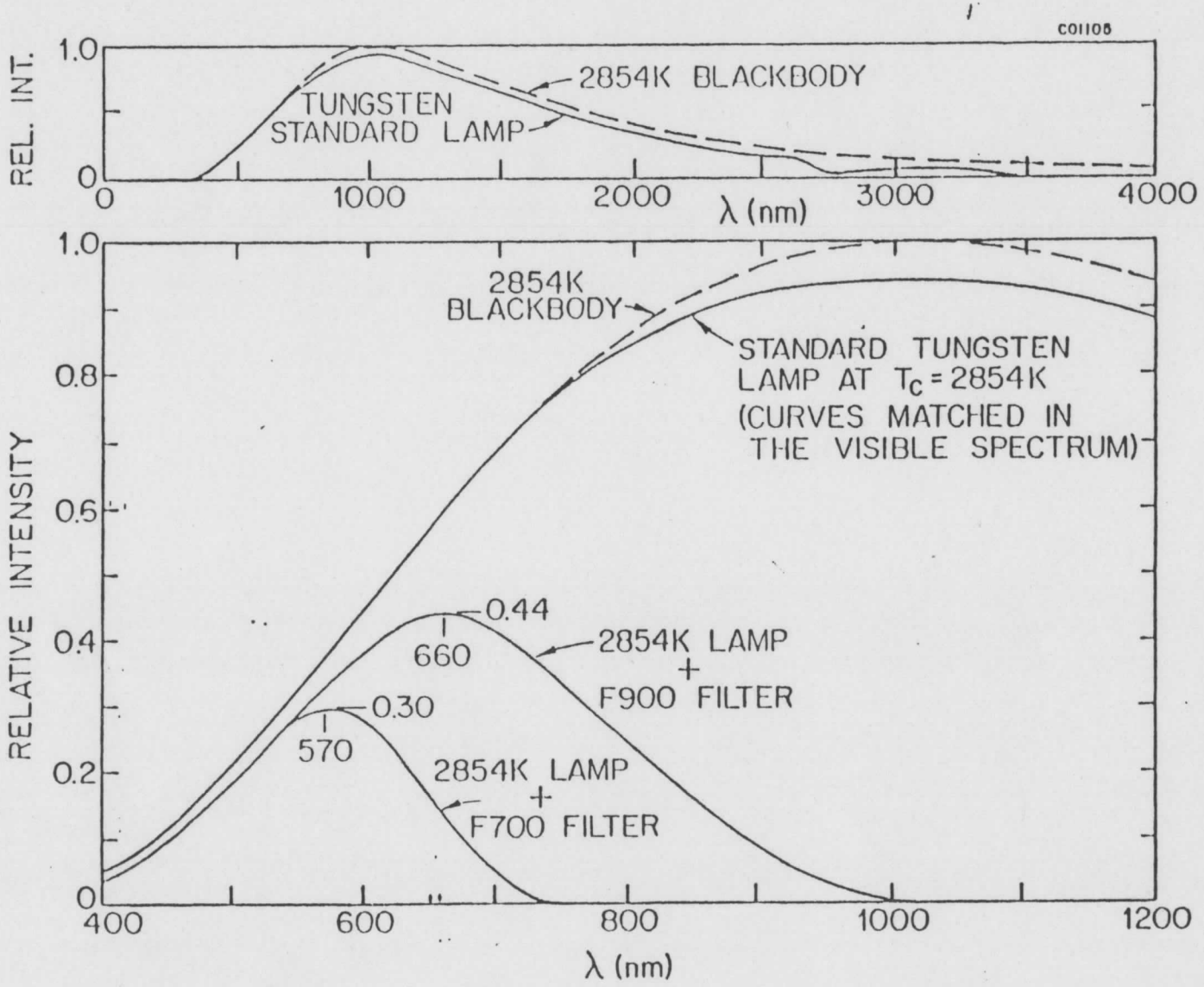
NOTE TECNICHE PER OTTICA

THEORETICAL INTERNAL SPECTRAL RESPONSE FOR PHOTOSENSORS (25°C)




C01109
1000
100
10
R (mA/W)
400
600
800
1000
λ (nm)
Q.E. = 100%
50%
10%
5%
LINE SCAN DEVICES – TYPE II
LINE SCAN DEVICES – TYPE I
TV – TYPE DEVICES

SPECTRA OF THREE BROADBAND LIGHT SOURCES



Typical Internal Responsivities of Fairchild CCD Image Sensors

Type of Radiation	Responsivity (mA/W) Line-Scan Devices Type I	Type II	TV-Type Devices
2854°K, Unfiltered (1)	≈60	≈100	≈25
2854°K + F900 Filter (2)	170	300	60
2854°K + F700 Filter (3)	140	250	45
Monochromatic, 600nm	180	300	60

Notes: (1) $1\mu J/cm^2$ = 0.22 lux·sec.

(2) $1\mu J/cm^2$ = 1.5 lux·sec. The F900 filter blocks wavelengths above approximately 900 nm. It is a Corning 1-75 glass filter 3 mm thick.

(3) $1\mu J/cm^2$ = 3.0 lux·sec. The F700 filter blocks wavelengths above approximately 700nm. It is a Schott BG-38 glass filter 2mm thick.

TABLE II.3-2 SATURATION EXPOSURE LEVELS OF FAIRCHILD CCD IMAGE SENSORS(1)

	SATURATION EXPOSURE LEVEL					
DEVICE TYPE	CCD111	CCD121H	CCD122 CCD142	CCD133 CCD143	CCD211 CCD221	
SPECTRAL TYPE	I	I	II	II	III	Units
SATURATION CHARGE LEVEL	$1.0X10^6$	$1.2X10^6$	$1.3X10^6$	$1.4X10^6$	$3X10^5$	el/pixel
TYPE OF SOURCE SPECTRUM						
2854°K, unfiltered (2)						lux · sec
Photometric	0.25	0.35	0.25	0.35	0.10	
Radiometric	1.2	1.5	1.2	1.6	0.50	$\mu J/cm^2$
2854°K + F900 Filter (3)						lux · sec
Photometric	0.60	0.80	0.60	0.80	0.30	
Radiometric	0.40	0.55	0.40	0.55	0.20	$\mu J/cm^2$
2854°K + F700 Filter (4)						lux · sec
Photometric	1.5	2.0	1.5	2.0	0.80	
Radiometric	0.50	0.67	0.50	0.67	0.28	$\mu J/cm^2$
Monochromatic, 600nm	0.60	0.80	0.60	0.80	0.35	$\mu J/cm^2$

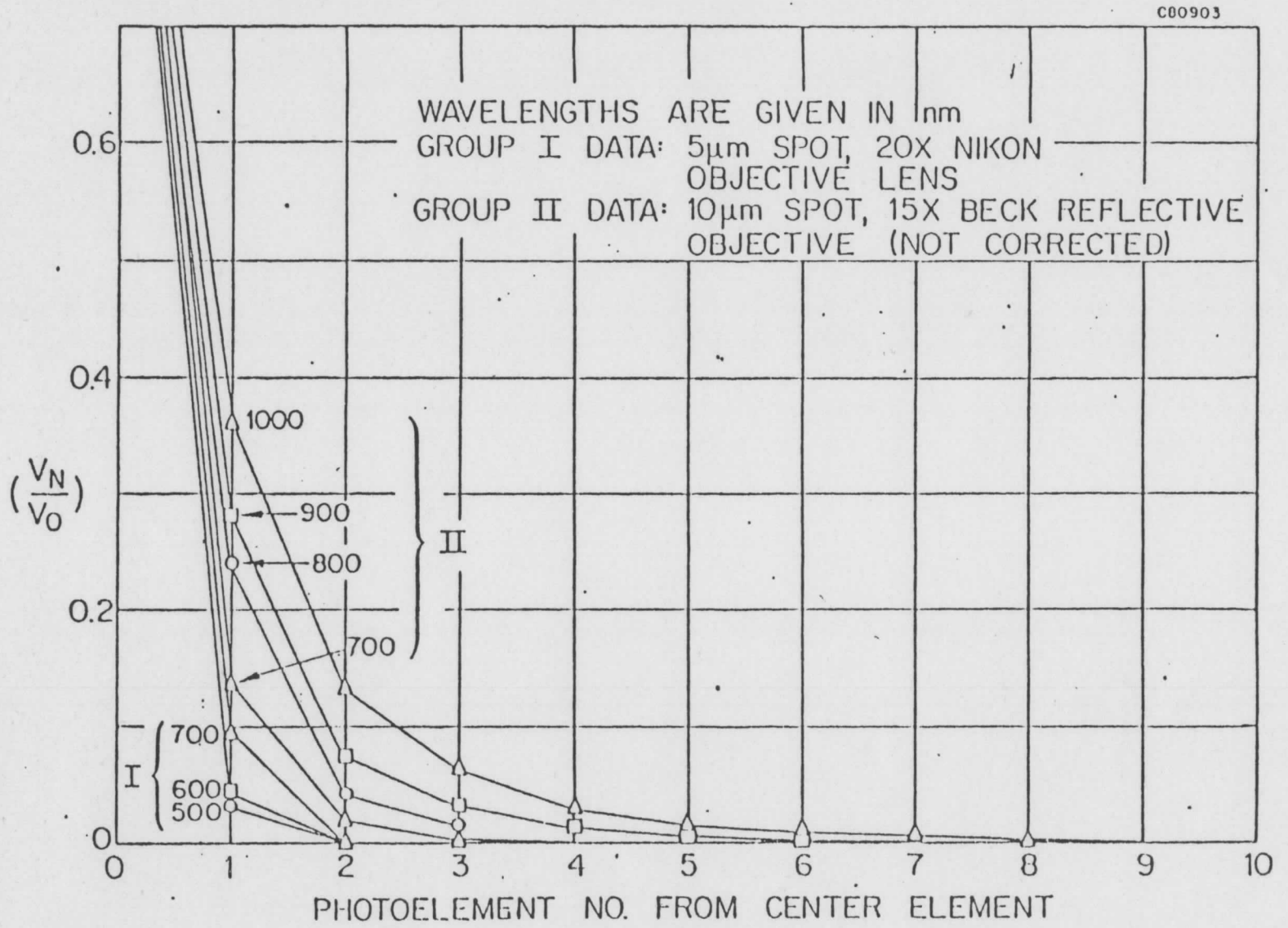
Notes: (1) Based on the "typical" values given in the respective data sheets, except for the CCD121H. The basis values are underlined.

(2) $1\mu J/cm^2$ = 0.22 lux · sec

(3) $1\mu J/cm^2$ = 1.5 lux · sec. The F900 filter blocks wavelengths above approximately 900 nm. It is a Corning 1-75 glass filter 3mm thick.

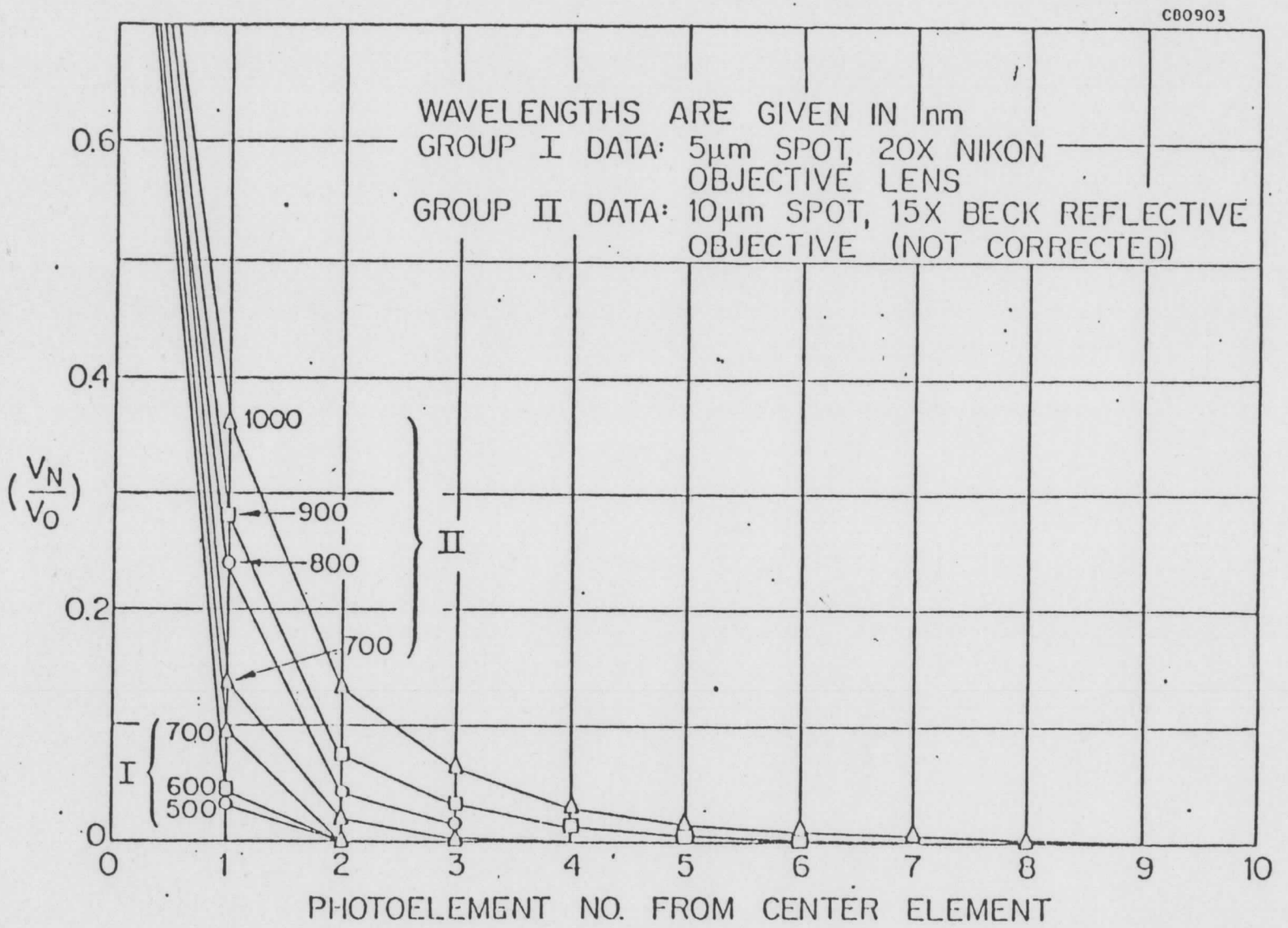
(4) $1\mu J/cm^2$ = 3.0 lux · sec. The F700 filter blocks wavelengths above approximately 700 nm. It is a Schott BG-38 glass filter 2mm thick.

OPTICAL CROSSTALK OF A TYPICAL CCD121H LINE-SCAN IMAGE SENSOR CHARACTERIZED USING A LIGHT SPOT



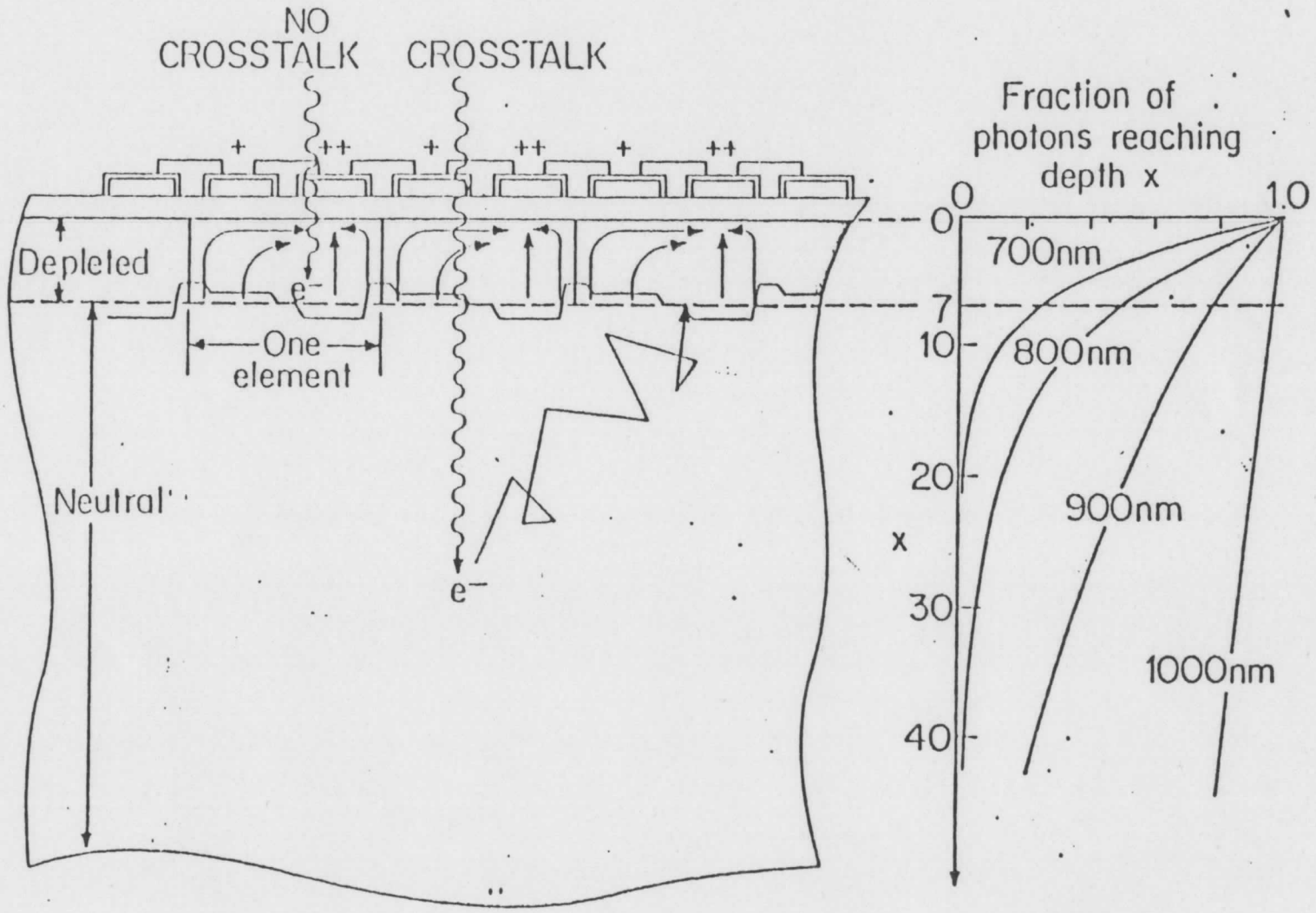
FAIRCHILD

OPTICAL CROSSTALK OF A TYPICAL CCD121H LINE-SCAN IMAGE SENSOR CHARACTERIZED USING A LIGHT SPOT



FAIRCHILD

CROSSTALK OF DEEP CARRIERS IN CCD IMAGE SENSOR



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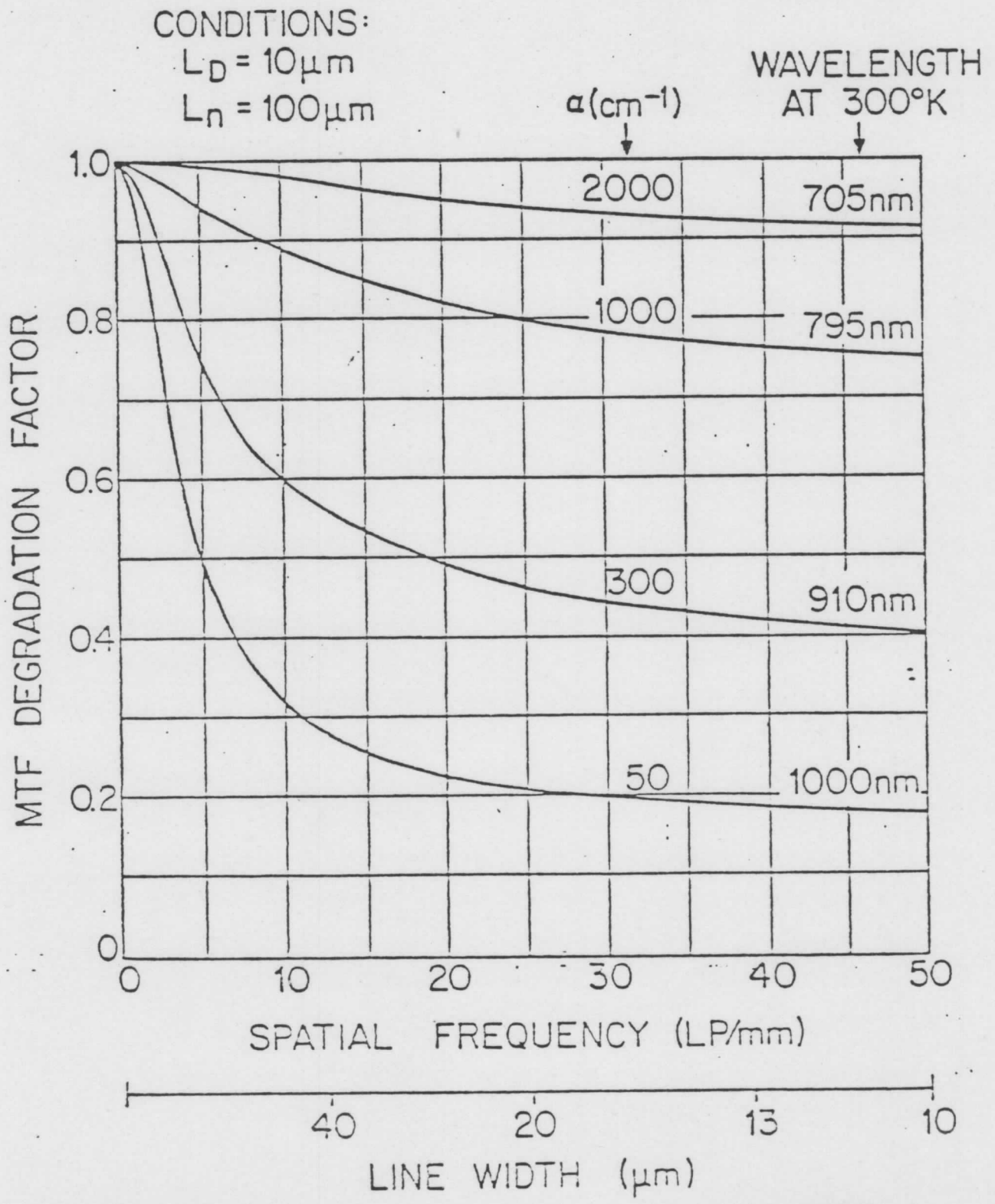
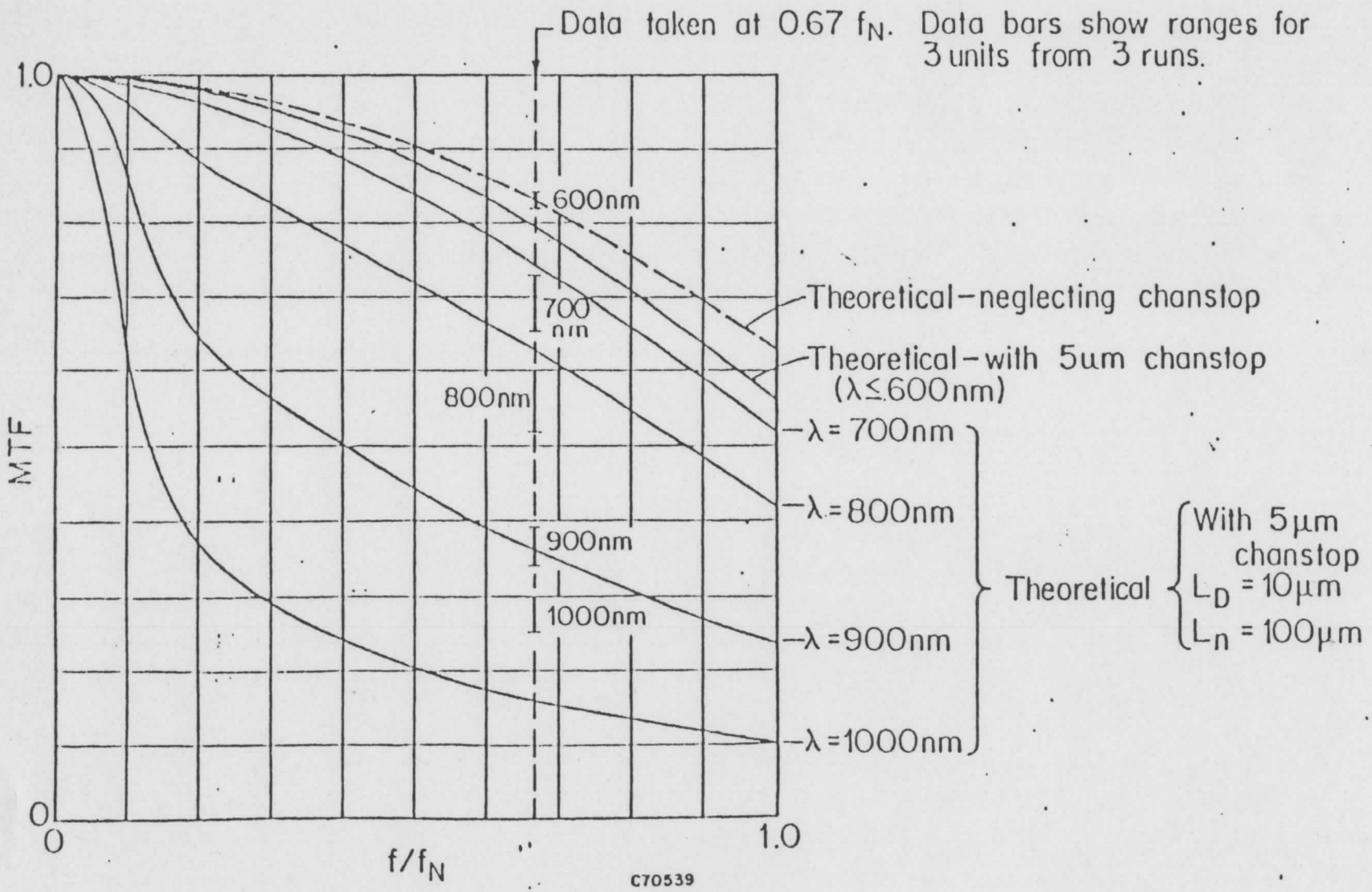
FAIRCHILD

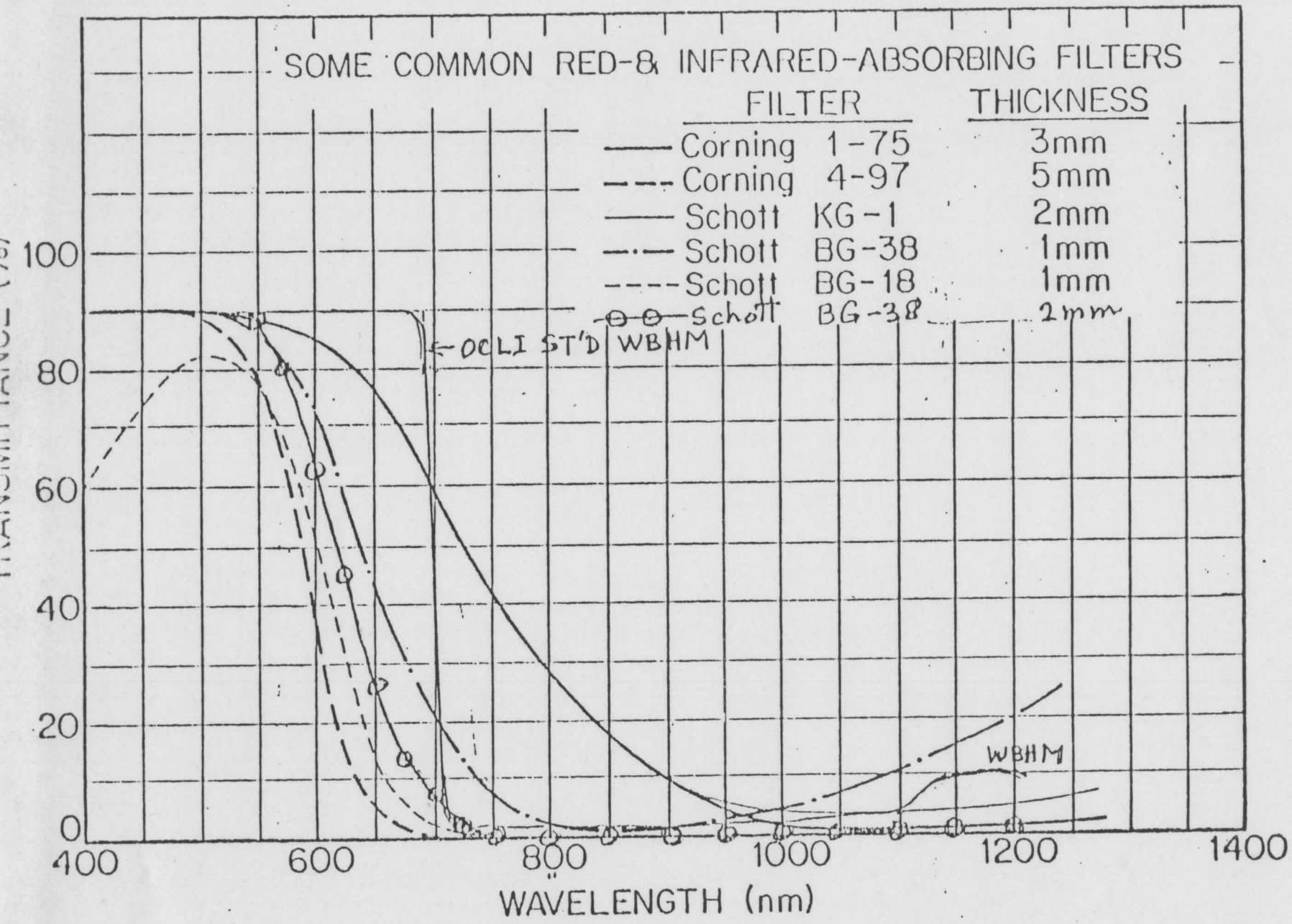
CALCULATED MTF DEGRADATION FACTOR vs. SPATIAL FREQUENCY AND WAVELENGTH



MTF vs. SPATIAL FREQUENCY FOR A CCD LINE IMAGE SENSOR WITH 13μm ELEMENT SPACING



FAIRCHILD

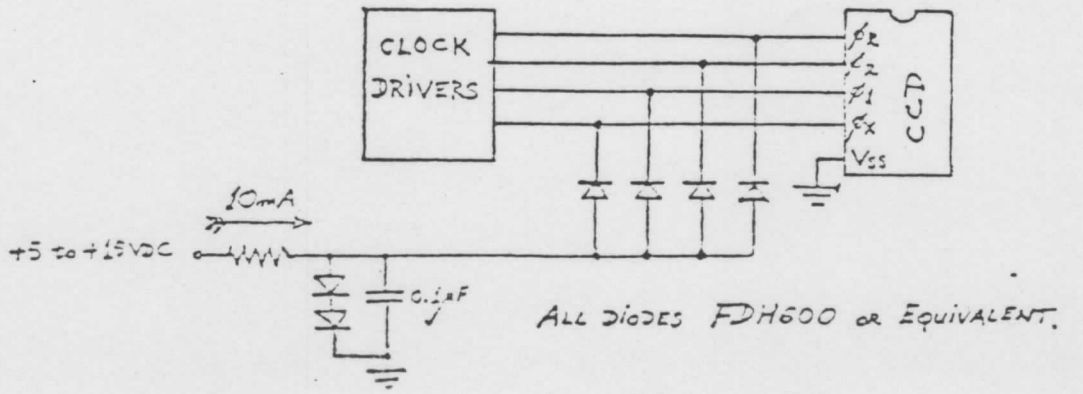

SOME COMMON RED-& INFRARED-ABSORBING FILTERS
FILTER
THICKNESS
Corning 1-75
3mm
Corning 4-97
5mm
Schott KG-1
2mm
Schott BG-38
1mm
Schott BG-18
1mm
Schott BG-38
2mm
← OCLI ST'D WBHM
WBHM
100
80
60
40
20
0
400
600
800
1000
1200
1400
WAVELENGTH (nm)

Charge Injection: Every input pin has a Gate Protection Structure which includes a diode from the input to the (grounded) substrate V_{ss}. The diode is reverse-biased during normal operation ($V_{in} \geq V_{ss}$). Negative (transient) input voltages ($V_{in} < V_{ss}$) will forward-bias the diode, injecting electrons into the bulk silicon of the CCD chip.

If sufficient charge is injected, it will accumulate in the CCD Analog Shift Register(s) and/or the Photosites near the injecting Gate Protection Structure(s). Injected charge which accumulates in the photosites will typically result in an apparent bell-shaped increase in the Background Dark Signal (FWHM ≈ 20-100 pixels wide) near the injecting Gate Protection Structure. Injected charge which accumulates in an Analog Shift Register will result in an apparent uniform increase in that register's Background Dark Signal, creating a noticeable increase in the apparent Register Imbalance ("odd/even") of the Background Dark Signal.

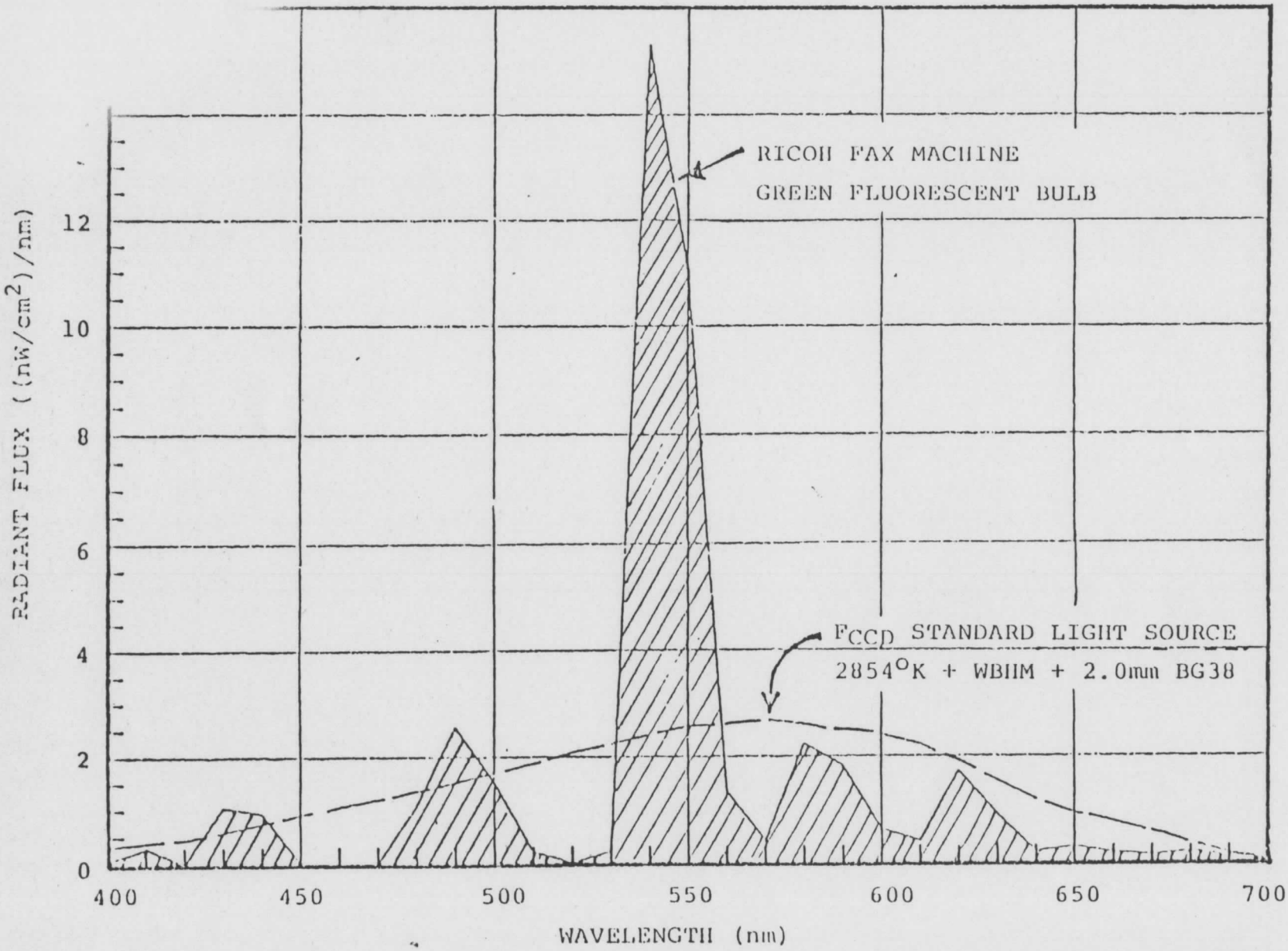
The susceptability to charge injection sufficient to increase the Background Dark Signal varies significatly from device to device. It is not possible to select devices with "low" susceptability. However, devices with low Dark Signal are typically more susceptable than devices with high Dark Signal.

Sufficient charge to appear as increased Background Dark Signal may be injected by negative transient voltages <4 ns long. Since these transients cannot be detected by oscilloscopes with less than 250-500 MHz bandwidth, a system which appears to be free from negative transients on a 200 MHz 'scope may still be prone to charge injection. The recommended method to eliminate charge injection is the following diode clipper circuit:

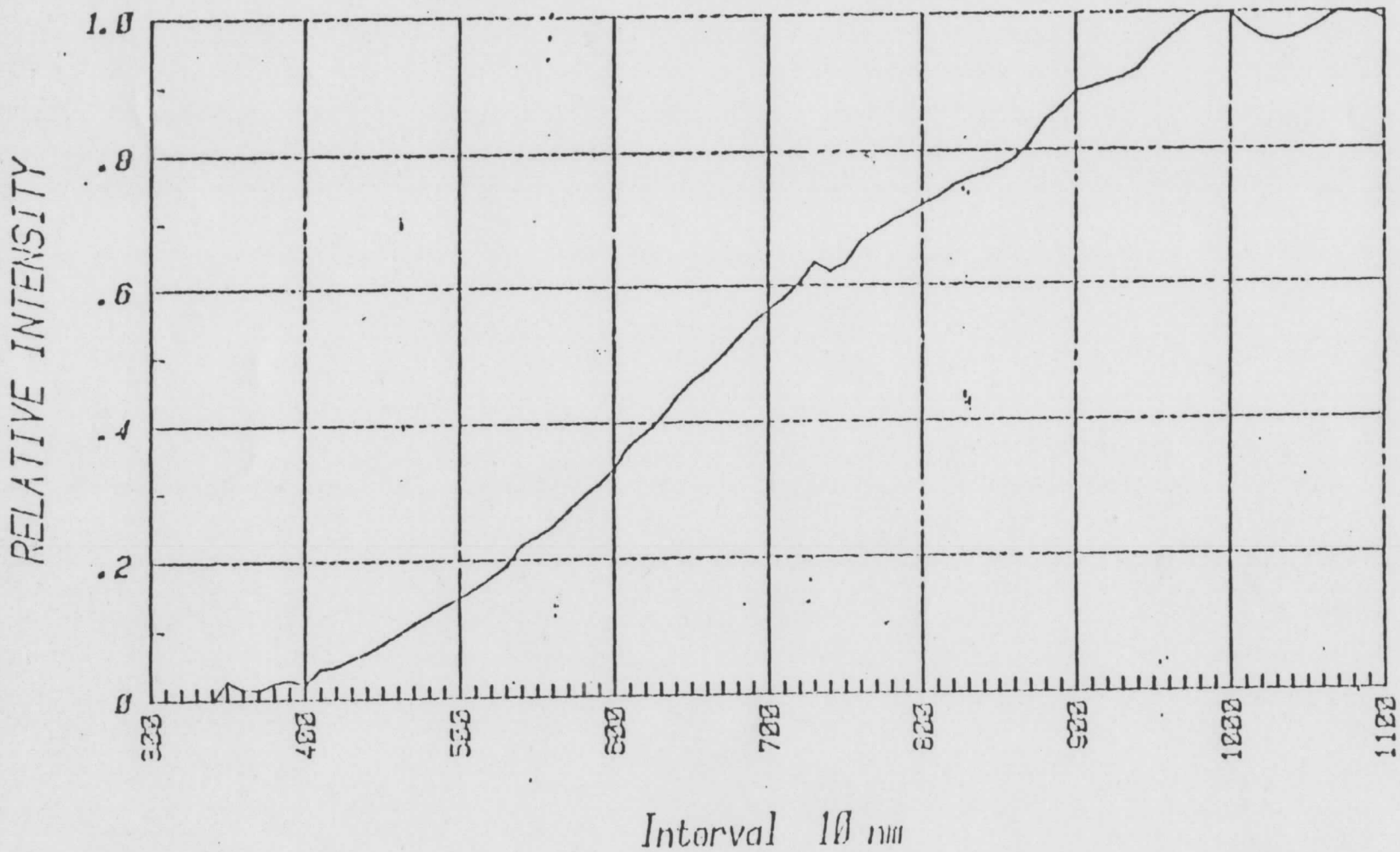


URCE versus F_{CCD} STANDARD 2854°K + WBIIM + BG38 FILTERS

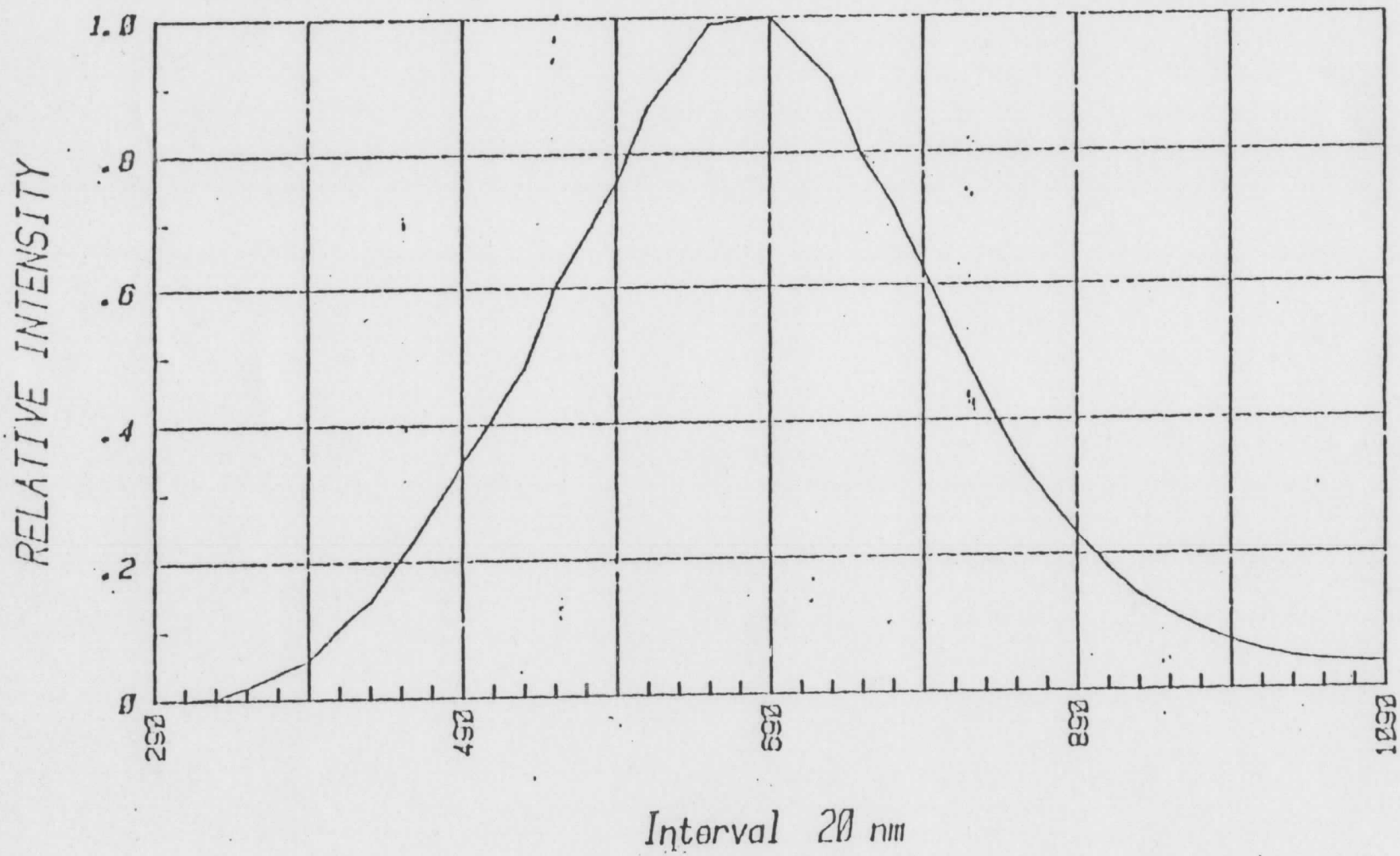
RADIANT FLUX FROM EACH LIGHT SOURCE IS 0.441$\mu W/cm^2$.



SPECTRAL INTENSITY
2854K HALOGEN Light Source

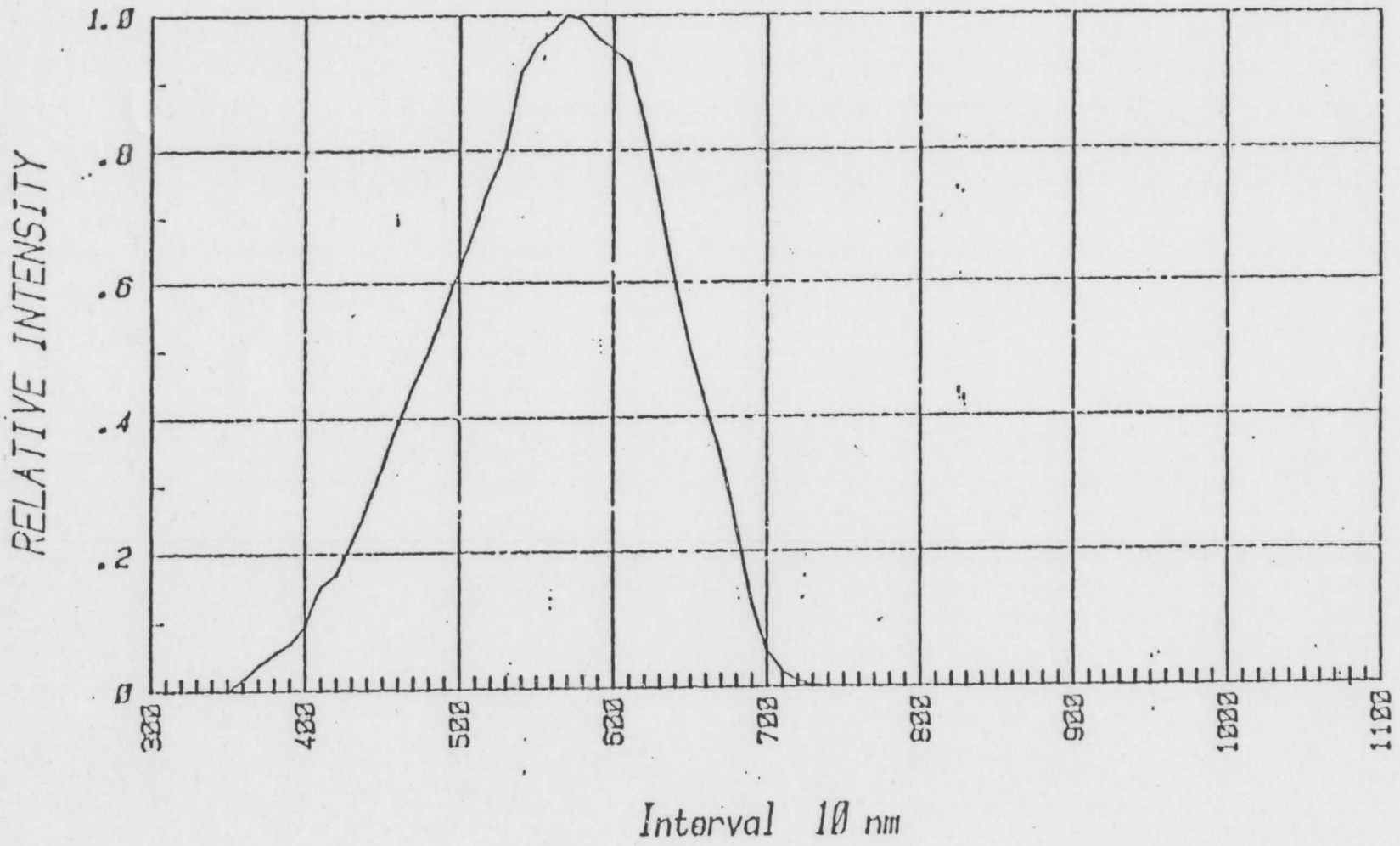


SPECTRAL INTENSITY
2854 + 1-75 Light Source



SPECTRAL INTENSITY

WBHM + BG-38 Light Source



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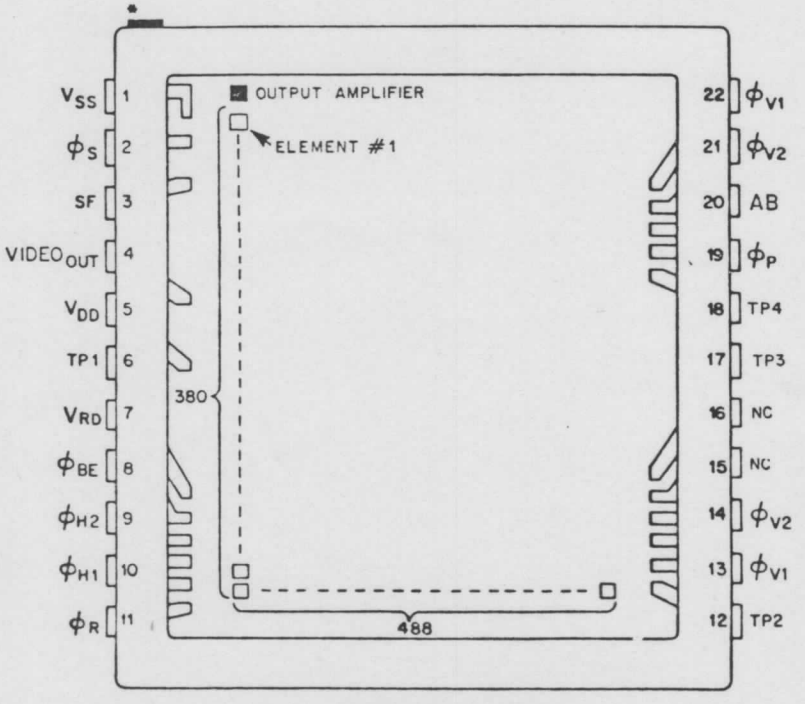
CCD222 VS CCD221 COMPARISON

The CCD222 is similar to the CCD221, but incorporates some important design modifications that result in dramatically improved background dark signal or dark signal shading. The output amplifier has been changed to be resettable improving the stability of the sensor output DC level. Also, the opaque metallization covering the first five columns used for dark signal referencing in the CCD221 has been removed enabling the entire 380 columns to become photoresponsive.

Although still packaged in the same 22-pin ceramic package, the pin configuration has been slightly modified to that shown in the connection diagram.

With higher volumes of production now being achieved, Fairchild has been able to improve the cosmetic performance specifications on the three classes of the CCD222 to those shown in the accompanying table.
All other data remains consistant with the CCD221.

CONNECTION DIAGRAM
(TOP VIEW)



CCD222

o PIN 1 (V_{SS}) IS DESIGNATED BY A DOT ON SIDE OF PACKAGE

V_{RD} on Pin 7 should be tied to a DC level of 4.0V.
ϕ_R on Pin 11 should be tied directly to the ϕ_{V1} clock on Pins 13 and 22 to achieve the necessary reset clock waveform.

Although device works well with timing shown in CCD221 data sheet, an optimized scheme is recommended in the CCD222 data sheet.

COSMETIC PERFORMANCE SPECIFICATIONS

CHARACTERISTIC	CCD222A MAX	CCD222B MAX	CCD222C MAX	CCD221A MAX	CCD221B MAX	CCD221C MAX	
NUMBER OF SINGLE POINTS BLEMISHES	5	100	200	100	200	300	
LARGEST SPB DIMENSION	2	3	5	3	5	8	Contiguous Pixels
NUMBER OF BLEMISHED PIXELS IN SPB's	10	100	200	*	*	*	
NUMBER OF COLUMN DEFECTS	0	4	6	4	6	10	
WIDEST COLUMN DEFECT WIDTH	0	2	2	2	3	4	Adjacent Columns
NUMBER OF SHEET COLUMN DEFECTS	8	8	8	0	1	2	
LONGEST SCD LENGTH	*	*	*	0	32	00	Lines
WIDEST SCD WIDTH	*	*	*	0	4	8	Columns
NUMBER OF DEFECTIVE COLUMNS	0	4	8	*	*	*	

*NOT A SPECIFIED PARAMETER

PERFORMANCE SPECIFICATION IMPROVEMENT: 30 frames/sec
t_{int} = 33.3 ms, Tc = 0.°C

SYMBOL	PARAMETER	CCD222			CCD221			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
DSSNU	DARK SIGNAL SHADING NON-UNIFORMITY		0.2	2		1	10	% V_{SAT}

OBJECTIVE SPEC FOR ROBOTIC AID

Number of pixels	256 horizontal x 256 vertical
Pixel size	22μm x 22μm
Photo sensing area	9μm (horizontal) x 20μm (vertical) 37%
Well Size	$127\mu m^2$
Qsat	258 Ke (at 3.5V barrier)
Vsat	1 Volts
Output Amplifier	GCI with AGC (Option Low Capacitance GCI)
Signal to Noise Ratio	50 db
Responsivity	$3.56\mu j\ cm^{-2}$
Sat. Scene Illumination	117 lux
Scene Illumination for 20ke	9.1 lux (short noise = 40 db)
Blooming Control	Element
Max. Output Rate	10 MHz
Chip Size	$7x7\ (mm)^2$ or 280 x 280 mil^2
Peripheral Response	< 1%

MADE IN
FAIRCHILD

APPLICATION NOTE

OPERATION OF THE CCD 211 AND CCD 221 IN THE NON-INTERLACED MODE

Normal operation of these devices produces two vertically interlaced fields per frame. This interlaced mode of operation is the highest resolution mode; it is the only way to obtain 244 TV lines of resolution vertically from the CCD 211 and 488 from the CCD 221.

This Application Note describes how, by sacrificing half of the vertical resolution, these devices can be operated in the non-interlaced mode. In this non-interlaced mode each picture element (pixel) consists of a pair of the normal pixels, one located just above the other. Thus the new pixels have a vertical spacing of 36μm and the normal horizontal spacing of 30μm.

For applications involving image analysis, pattern recognition, etc., the non-interlaced mode may be advantageous. Not only is there the advantage that any small portion of the raster is scanned all at once, but the new pixel is more nearly square (5:6 aspect ratio) than the normal one (3:5 aspect ratio).

The only difference in the clock drive signals from normal two-field-per-frame operation is that the two vertical transport clocks, ϕ_{V1} and ϕ_{V2}, must be modified in waveform so that, during each photogate LOW pulse, both are in the HIGH state. This moves all of the charge packets from their respective pixel locations into separate sites in the vertical shift registers. Following this step, when the first vertical transport clock goes LOW, the charge packets pair up as half of them move from the LOW phase upward into the adjacent HIGH phase. After this, everything proceeds normally until the next photogate LOW pulse.

0.120 REF.
(3.05)
SIDE BRAZE PIN
HEADER
0.285 REF.
(7.24)
0.010
(0.254)
0.600 REF.
(15.24)

VERTICAL CONTRAST TRANSFER FUNCTION FOR TWO BROADBAND ILLUMINATION SOURCES
NORMALIZED SPATIAL FREQUENCY
SPATIAL FREQUENCY — CYCLES/mm
2854°K ALONE
2854°K + BG-38 FILTER

TYPICAL ILLUMINATION LEVEL RANGES
FOR THE CD222 IMAGE SENSOR IN AN OPTIMUM CAMERA
DEVICE ILLUMINATION LEVEL (lux)
SCENE ILLUMINATION LEVEL WITH F2 LENS (lux)
SATURATION LEVEL
DAYLIGHT (5500°K) W/O FILTER
2800°K WITH IR FILTER (BG-38)
2800°K W/O FILTER
OUTPUT VOLTAGE (mV)
INTERNAL SIGNAL (electrons/pixel)
(BELOW ≈5°C)
(25°C)
(40°C)
5000:1
1000:1
300:1
AVERAGE DARK SIGNAL
TYPICAL DARK SIGNAL NON-UNIFORMITIES
RMS NOISE
T(°C)
RHD 3-5-82

FAIRCHILD
A Schlumberger Company

CCD

APPLICATION NOTE

OPERATION OF THE CCD222 IN THE NON-INTERLACED MODE

Normal operation of the CCD222 device produces two vertically interlaced fields per frame. This interlaced mode of operation is the highest resolution mode; it is the only way to obtain 488 TV lines of resolution vertically from the CCD222.

This Application Note describes how, by sacrificing half of the vertical resolution, the CCD222 device can be operated in the non-interlaced mode. In this non-interlaced mode each picture element (pixel) consists of a pair of the normal pixels, one located just above the other. Thus the new pixels have a vertical spacing of 36μm and the normal horizontal spacing of 30μm.

For applications involving image analysis, pattern recognition, etc., the non-interlaced mode may be advantageous. Not only is there the advantage that any small portion of the raster is scanned all at once, but the new pixel is more nearly square (5:6 aspect ratio) than is the normal one (3:5 aspect ratio).

The only difference in the clock drive signals from normal two-field-per-frame operation is that the two vertical transport clocks, ϕ_{V1} and ϕ_{V2}, must be modified in waveform so that, during each photogate LOW pulse, both are in the HIGH state. This moves all of the charge packets from their respective pixel locations into separate sites in the vertical shift registers. Following this step, when the first vertical transport clock goes LOW, the charge packets pair up as half of them move from the LOW phase upward into the adjacent HIGH phase. After this, everything proceeds normally until the next photogate LOW pulse.

R. H. Dyck
6/29/82

OPERATION OF THE CCD222 IN A THREE-FIELD-PER-FRAME MODE FOR HIGH-ENERGY APPLICATIONS

The CCD222 can be used for imaging electrons ($\gtrsim$ 5 KeV), x-rays and other high energy particles, provided that it is procured without a window. However, in general, there is a problem due to the fact that the aluminum opaquing over the column registers is not opaque to these particles. Therefore, special precautions or special modes of operation are required. The mode of operation described here is of interest in that it recovers the maximum amount of image information.

This mode of operation is best thought of as a "snap-shot" mode. First, the frame clock and vertical clocks are stopped, then the shutter or particle gate is opened briefly and closed again. At this time, the stored signal consists of a 488x380 array of charge packets in the photoelement sites plus a 244x380 array of charge packets in the vertical registers. Next, one field is scanned out of the device in normal fashion, but the frame clock is not pulsed first. This extracts the 244x380 field of information originating in the vertical registers. Next, the two-field frame is scanned out in normal fashion. Finally, the clocks are stopped to complete the cycle. The configuration of the three charge-collection areas in the unit cell is shown in the figure.

The clock drive conditions recommended for this mode are as follows:

During the "snap-shot", the frame clock, ϕP, and first vertical clock, $\phi V1$, are high and the second vertical clock, $\phi V2$, is low. (The horizontal clocks should be clocked if this period is more than one line-time.) All other clocking requirements are given in the CCD222 data sheet.

This mode of operation achieves the following:

1. 100% active area
2. Full vertical resolution
3. Twice the normal horizontal resolution

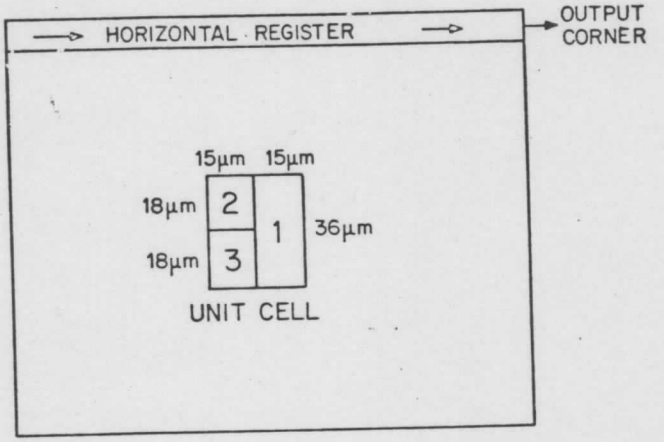
If the application is such that two or more "snap-shots" may be combined to produce the final image, then a similar six-field-per-frame mode of operation is the mode which recovers maximum information. The six-field-frame is made up of a three-field sequence as described above together with a second three-field sequence which is identical to the first except for the first field. In this second sequence, the vertical clocks are stopped 180 degrees out of phase from the first, resulting in a half-unit-cell shift of the center of the picture elements for the vertical registers.

FAIRCHILD
A Schlumberger Company

CCD

OPERATION OF THE CCD222 IN A THREE-FIELD-PER-FRAME MODE FOR HIGH-ENERGY APPLICATIONS

UNIT CELL CONFIGURATION IN THE CCD222 INDICATING THE THREE CHARGE COLLECTION AREAS



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